EMPIRICAL DETERMINATION OF RADIOLYTIC PRODUCTS IN SIMULATED EUROPAN ICES. K. P. Hand[1], R. W. Carlson[2], and C. F. Chyba[1,3] [1]Dept. Geological & Environmental Sciences, Stanford University, 450 Serra Mall, Building 320 Stanford, CA 94305, (khand@stanford.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 (rcarlson@lively.jpl.nasa.gov), [3]The SETI Institute, 2035 Landings Drive, Mountain View, CA, 94303 (chyba@seti.org).

Introduction: The chemical composition of Europa's surface is strongly influenced by energetic charge particle bombardment from Jupiter's magnetosphere. Here we report on progress in experimental work designed to address: 1) The production of radiolytic products in thermodynamic disequilibrium that could be utilized by known terrestrial microorganisms, and 2) The modification of complex organic molecules and degradation of biological material by the simulated Europan surface radiation environment.

Methods: The experimental facility includes a 500 eV – 20 keV electron gun in a vacuum chamber coupled to a continuous flow cryostat capable of maintaining temperatures in the range of 4 K – 320 K. The configuration of the electron gun chamber allows for simultaneous mass spectroscopy, Fourier transform IR-spectroscopy, UV flourescence, and UV transmission and reflectance. Water vapor and compound mixtures (e.g. propane, formaldehyde, alcohols…) are deposited on the cryostat plate and the resulting ice mixture is then bombarded with high energy electrons, simulating the Europan surface environment. Irradiations are performed at temperatures that simulate Europan conditions and chemical evolution of the samples is determined using mass spectroscopy and infrared spectroscopic measurements, both obtained throughout the exposure. High doses are achieved in order to establish equilibrium species.

Results: The most recent results from our work are presented. In particular, two sets of experimental results are considered.

Disequillibrium products: We have undertaken an experimental determination of the chemicals that are produced by high-dose irradiation of ice containing impurities relevant to Europa. Radiolysis produces molecular species in thermodynamic disequilibrium [1, 2, 3], and these may in turn be used by organisms in energy-producing reactions, forming a radiation-driven ecosystem as hypothesized by Chyba [4] and Chyba and Hand [5]. Here we determine the production rates and equilibrium concentrations for products such as formaldehyde, methane, oxygen, organic molecules, and thiols from irradiated ice containing compounds of carbon, sulfur, and silicate. Delivery of such compounds to the putative ocean and the metabolic utility of these radiolytic products is also considered.

Modification of biosignatures: The second component of this work is an analysis of the radiolytic modification of chemical biosignatures. High-energy radiation decomposes molecules on Europa, even to depths of several meters. A rough mean dose for material in the upper 10 cm of the ice shell is on the order of 10^4-10^5 eV per 16 amu, enough to ionize and dissociate all molecular species several times over [6, 7].

A prime measurement goal for an astrobiology mission orbiting or landing on Europa is determination of the surface and subsurface, searching for complex organic molecules that may serve as biosignatures. Determining the depth required for obtaining useful biosignature molecules requires a systematic study of candidate molecules, irradiated in ice at Europa-like temperatures. Here we examine the products of such exposure on a variety of organic molecules, biological compounds, and some microorganisms contained within the simulated Europan ice matrix. By varying dose rate we simulate various depths below the ice shell surface and yield results for survivability of biosignatures in the ice shell.

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